Treatment of NH_4NO_3 laden condensate for re-use as boiler feed water – from lab to pilot scale

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Keywords: Condensate, desalination, re-use

Introduction

Increasing fresh water shortages (caused for example by groundwater salinization) worldwide push major industries to look for alternative water sources. However, alternative water sources bring with it uncertainties related to quality, quantity and the related effect on existing water (pre-)treatments and the industrial processes itself.

One of the processes sensitive to water quality is the boiler in steam-water cycles. In this research, the re-use of a process condensate contaminated with NH_4NO_3 is investigated. Different technologies are investigated first on lab-scale and then pilot-scale to investigate their technological and economic potential for full-scale application.

The IMPROVED project

This research is conducted as part of the Interreg IMPROVED project (Integral Mobile PROcesswaterproduction For an Economic Delta), which entails the design, build and exploitation of a mobile testing infrastructure containing several water treatment installations to be put on site of three large chemical companies. This allows flexible on-site testing of several technologies under realistic conditions. Figure 1 depicts the technologies available in the infrastructure. The treatments used in the case of the NH_4NO_3-condensate are indicated in bold.

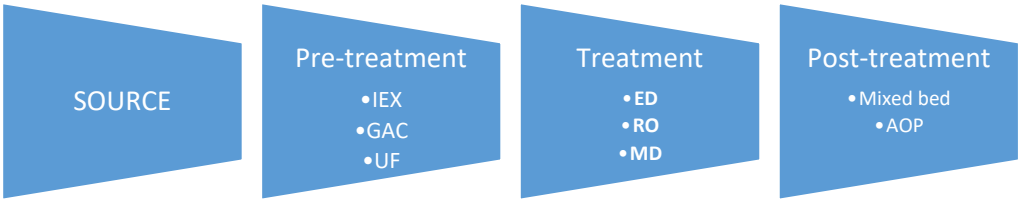

Figure 1. Technologies available in the IMPROVED infrastructure. IEX = ion-exchange, GAC = granular activate carbon, UF = ultrafiltration, ED = electrodialysis, RO = reverse osmosis, MD = membrane distillation, AOP = advanced oxidation processes

Material and Methods

Electrodialysis (ED), reverse osmosis (RO) and membrane distillation (MD) were tested for 3 months in total to treat the NH_4NO_3-condensate and obtain a reusable water stream.A short description of all set-ups will be given here.

ED lab-scale: PCCell ED 64004, 5 cell-pairs, Fujifilm Type I membranes.

ED Pilot-scale: PCCell ED 1000A, 25 cell-pairs, PCA membranes, feed-and-bleed mode

RO Lab-scale: flat sheet BW30HR-440i Dow membrane (24.5x4.5 cm^2)

RO Pilot-scale: LC HR4040 module.

Both MD modules were obtained from Aquastill, the exact properties are confidential.

Results and Discussion

Lab-scale experiments

During the lab-scale experiments, two parameters were important and monitored: NH_4 and NO_3 removal from the feed stream. Table 1 shows the removal of these compounds for the different technologies on lab-scale.

Table 1. Removal efficiency (%) of NH_4 and NO_3 by electrodialysis (ED), reverse osmosis (RO) and membrane distillation (MD). Since NO_3 is not volatile, it is not removed in MD.

	ED (%)	**RO (%)**	**MD (%)**
NH_4	98	76	55
NO_3	94	75	-

Mobile testing unit

As ED and RO showed the most promising results in terms of water quality, these were tested in the mobile unit on-site. ED achieved a desalination of around 85% and RO ran at a stable recovery of 75%.

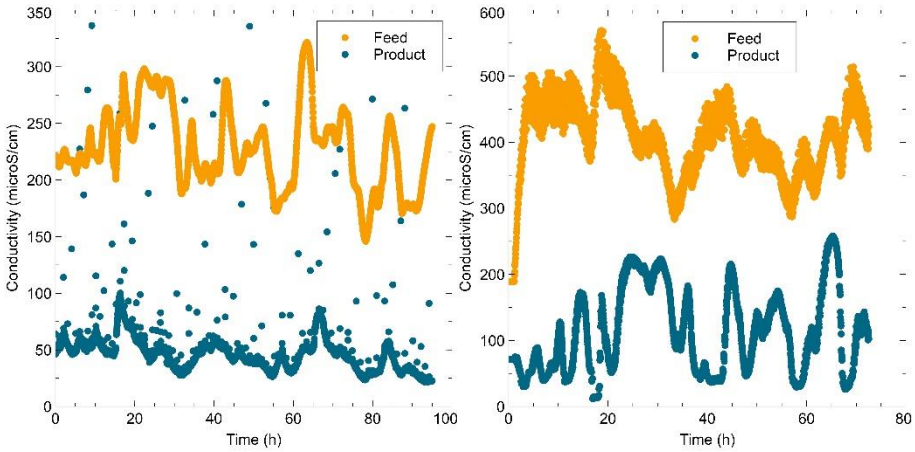

Figure 1. Feed and product conductivity for ED (left) and RO (right) for part of the testing period. In RO, the feed conductivity increases rapidly in the beginning due to recirculation of the concentrate.

Conclusions

It is possible to treat a contaminated condensate stream by ED and RO and run a stable operation on pilot scale for an extended time. The product quality reached after ED is generally higher. However, it is yet to be determined if this quality is sufficient for steam-water cycles.